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Research Product 81-27

DEVELOPMENT OF DESIGN GUIDELINES AND CRITERIA FOR USER/OPERATOR TRANSACTIONS WITH BATTLEFIELD AUTOMATED SYSTEMS

VOLUME III-B:

HUMAN FACTORS ANALYSIS OF USER/OPERATOR TRANSACTIONS WITH TCT--TACTICAL COMPUTER TERMINAL

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February 1981

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A Field Operating Agency under the Jurisdiction of the Deputy Chief of Staff for Personnel

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Research accomplished under contract
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Synectics Corporation

REPORT DOCUMENTATION PAGE

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This document is one of a series in the Final Report of Phase I in a project to develop design guidelines and criteria for user/operator transactions with battlefield automated systems. The report is organized in five volumes as follows:

Item 20 (Cont'd)

I. Executive Summary (RR 1320)
II. Technical Report (TR 536)
III. In-Depth Analyses of Individual Systems
  A. Tactical Fire Direction System (TACFIRE) (RP 81-26)
  B. Tactical Computer Terminal (TCT) (this report)
  C. Admin/Log Automated Systems (RP 81-28)
  D. Intelligence Information Subsystem (IISS) (RP 81-29)
IV. Provisional Guidelines and Criteria (TR 537)
V. Background Literature (TR 538)

Volume I presents a succinct review of activities and products of the project's first phase. Volume II contains a technical discussion of the project's objectives, methodologies, results, conclusions, and implications for the design of user/operator transactions with battlefield automated systems. Volume III documents analyses of four unique battlefield automated systems selected to represent different stages of system development and different Army functional areas. Volume IV presents provisional guidelines and criteria for the design of transactions. Volume V provides a brief review of selected literature related to guidelines and criteria.

Research Product 81-27

DEVELOPMENT OF DESIGN GUIDELINES AND CRITERIA FOR USER/OPERATOR TRANSACTIONS WITH BATTLEFIELD AUTOMATED SYSTEMS

VOLUME III-B:

HUMAN FACTORS ANALYSIS OF USER/OPERATOR TRANSACTIONS WITH TCT--TACTICAL COMPUTER TERMINAL

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2Q263744A793

Human Performance Effectiveness
and Simulation

FOREWORD

The Human Factors Technical Area of the Army Research Institute (ARI) is concerned with helping users and operators cope with the ever increasing complexity of the battlefield automated systems by which they acquire, transmit, process, disseminate, and utilize information. Increased system complexity increases demands imposed on the human interacting with the machine. ARI's efforts in this area focus on human performance problems related to interactions with command and control centers, and on issues of system design and development. Research is addressed to such areas as user-oriented systems, software development, information management, staff operations and procedures, decision support, and systems integration and utilization.

An area of special concern in user-oriented systems is the improvement of the user-machine interface. Lacking consistent design principles, current practice results in a fragmented and unsystematic approach to system design, especially where the user/operator-system interaction is concerned. Despite numerous design efforts and the development of extensive system user information over several decades, this information remains widely scattered and relatively undocumented except as it exists within and reflects a particular system. The current effort is dedicated to the development of a comprehensive set of Human Factors guidelines and evaluation criteria for the design of user/operator transactions with battlefield automated systems. These guidelines and criteria are intended to assist proponents and managers of battlefield automated systems at each phase of system development to select the design features and operating procedures of the human-computer interface which best match the requirements and capabilities of anticipated users/operators.

Research in the area of user-oriented systems is conducted as an in-house effort augmented through contracts with uniquely qualified organizations. The present effort was conducted in collaboration with personnel from Synectics Corporation under contract MDA903-80-C-0094. The effort is responsive to requirements of Army Project 2Q263744A793, Human Performance Effectiveness and Simulation, and to special requirements of the U.S. Army Combined Arms Combat Developments Activity (CACDA), Fort Leavenworth, Kansas.

JOSEPH ZEIDNER
Technical Director

DESIGN GUIDELINES AND CRITERIA FOR USER/OPERATOR TRANSACTIONS WITH BATTLEFIELD AUTOMATED SYSTEMS VOLUME III-B: HUMAN FACTORS ANALYSIS OF USER/OPERATOR TRANSACTIONS WITH THE TACTICAL COMPUTER TEMINAL (TCT)

EXECUTIVE SUMMARY

Requirement:

To develop a comprehensive set of human factors guidelines and criteria for the design of user/operator transactions in battlefield automated systems for use by human factors specialists and system proponents, managers, and developers.

Procedure:

To provide data for a baseline function description of user/operator transactions in battlefield automated systems, user-computer interactions in TCT were analyzed using a Transaction Feature Analysis technique. Data were collected during interviews with system experts and reviews of system documentation. The analysis focused on system design features that affect user/operator performance of transactional tasks.

Findings:

No major problems or deficiencies were found in the TCT user-computer interface. TCT makes extensive use of menus and function keys to control the system. Standard terms, character sets and labels, glossaries, abbreviations and codes are all available via menus/prompts which are easily accessed, comprehensive, and clear. However, the menus could be improved by a hierarchical format and language more meaningful to the user/operator. Numerous fixed and variable (programmable) function keys control a variety of operations. The system functions on a set of four well-designed message formats. Speedup of data entry into these formats could be accomplished by menu selection of routinely called-out sending and receiving units and by automatic entry of date/time data. Some modifications in system initialization, mode selection, and mode of operation designators are suggested to reduce the user/operator memory burden. System operation could also be improved with more specific error feedback.

Utilization of Findings:

Findings from the analysis of individual systems may be useful to proponents in specifying user/operator requirements for future system evolution. In this project, the findings were incorporated in a data base on human factors requirements which provided the "real world" foundation for development of the provisional guidelines and criteria presented in volume IV of this report. The provisional guidelines and criteria will be utilized as the basis for development of the prototype handbook.

SUMMARY

This document reports a human factors-oriented analysis of user/operator transactions with the Tactical Computer Terminal (TCT). Subject matter experts were interviewed and system documents were reviewed to learn about hardware, software, and procedural design features that affect those transactions. Observations were recorded with a Transaction Feature Analysis technique developed for this purpose. Transaction features analyzed with the technique were arranged by categories to facilitate presentation and discussion.

The analysis revealed no major problems or deficiencies in the TCT user-computer software feature; that is, no single reature was observed that by itself would be likely to degrade system performance seriously. In fact, a number of features were identified that would contribute to successful performance. Nonetheless, other features exist in the TCT that, while minor when considered alone, could combine under operational conditions to introduce errors into system outputs or delay completion of system functions. Improvements in these areas would reduce error rates and increase throughput rates. Perhaps equally important, they would also make the system easier to use; by providing a simpler, "friendlier" user/computer software interface, they could reduce training requirements.

Recommendations for such improvements are summarized in Table 1. The table is organized by categories of design features as described in the report. Each recommendation is evaluated, according to the best judgment of the analysts, in terms of hardware changes, software reprogramming, or changes in system operating procedures. Evaluations cannot be expressed in quantitative terms because appropriate data could not be collected. Therefore, the evaluation is expressed in terms of low (L), moderate (M) or high (H) impact on hardware, software, and performance, with a minus sign indicating negative impact (cost) and a plus sign indicating positive impact (benefit).

Table 1

Summary of Recommended Design Features and Extraction of Their Impact

CATEGORY	RECOMMENDATIONS	IMPACT*		
		Hardware	Software	User Operator/ Performance
1. CONTROL METHODS				
1.1 Command Language	N/A	N/A	N/A	N/A
1.2 Menus	None	-	-	-
1.3 Function Keys	. Eliminate unnecessary use of function keys	None	L-	M+
	. Use consistent function key sequences for similar functions	None	L-	M+
	. Label function keys with natural terminology	L-	L-	M+
1.4 Hybrid Methods	. Bring display prompts and function key labels into agreement	None	L-	L+
1.5 Prompts/HELPS	. Put optional systems in SITREP in REMARKS field, or	None	L-	M+
	. Provide hierarchical menu of crewed systems			
	. Provide automatic transition to mode selection after system initialization	None	L-	M+
	. Provide menu options in terms meaningful to user/ operator	None	L-	M+
	. Use information already input by user/operator to determine options presented in subsequent menus	None	M-	M+ or H+
	. Modify software so that functionally identical prompts are worded identically	None	L-	M+
2. DISPLAY FORMAT	NO PROBLEMS IDENTIFIED IN FOUR FORMATS CURRENTLY IN USE	-	-	-

*L = Low, M = Moderate, H = High impact; (+) = positive impact (benefit), (-) = negative impact (cost).

Table 1. Continued

CATEGORY	RECOMMENDATIONS	IMPACT* Hardware	Software	User Operator/ Performance
3. DATA ENTRY ASSISTANCE				
3.1 Information on Legal Entries	. Provide prompts indicating which FFKs are legal for TEXT EDIT mode, or	None	L-	M+
	. Provide a HELP capability allowing user/operator to determine legal FFKs in TEXT EDIT mode	None	M-	M+
3.2 Unburdening of Input	. Provide menu of units to allow selection of sending and receiving units of messages	None	L-	M+
	. Provide capability to enter date once a day and/or at system initialization and to pick up time from system clock	None	M-	M+
	. Provide prompts to assist user/operator to enter EFF-TIME	None	M-	M+
	. Provide capability to copy channel 1 data to channel 2 automatically when data are same for both channels	None	M-	M+
3.3 Interrupts and Work Recovery	. Provide capability to re-transmit a message automatically		M-	M+ or H+
4. MESSAGE COMPOSITION AIDS				
4.1 System Design Features	. Provide feedback for data entries in prompt area of screen		M-	M+
	. Provide default options for all system communications equipment		L-	M+
	. Modify software to include grid zone designation automatically into standard message formats	None	L- or M-	M+

Table 1. Continued

CATEGORY	RECOMMENDATIONS	IMPACT* Hardware	Software	User Operator/ Performance
4.2 Format for Alphanumeric Messages 4.3 Graphic Messages 5. DATA RETRIEVAL ASSISTANCE 6. GLOSSARIES 7. ERROR HANDLING 7.1 Prevention 7.2 Detection	NO TRANSACTION FEATURES WERE OBSERVED IN THESE CATEGORIES THAT REQUIRED TRANSACTION FEATURE ANALYSIS			
7.3 Feedback	. Provide explicit diagnostic information in error messages	None	M-	H+
7.4 Correction/Recovery	. Provide brief information on legal entries in error messages	None	M-	H+

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INTRODUCTION

This document reports a human factors-oriented analysis of user/operator transactions with the Tactical Computer Terminal (TCT). The TCT is an intelligent terminal; it is the first step in an evolutionary process to develop a Tactical Computer System (TCS) that will provide data processing support to tactical command and control.

As indicated above, the analysis focused on user/operator transactions. It therefore did not examine such traditional human engineering features as stroke width of characters, force-displacement characteristics of keys, color- or shape-coding of knobs and levers, control-display ratios, or arrangements of workplaces. Indeed, the analysis addressed both hardware and software only insofar as they affect user/operator transactions. Throughout the effort, the emphasis remained on transaction features such as command methods, display formats, data entry and handling, message composition, data retrieval, glossaries, error handling, and user/operator configurations.

This analysis of the TCT, and those of other systems listed in the Preface, served to validate information gathered during an earlier survey of Army battlefield automated systems. It also provides additional information for a data base on user/operator transactions initially developed from the earlier survey. This data base identifies and classifies problems and deficiencies in the human-computer software interface of battlefield automated systems. It will provide the foundation for developing guidelines and criteria for the design of user/operator transactions with future systems.

No attempt is made here to integrate the analysis of TCT with those of other systems. Such an integration clearly is required to permit the comparisons among systems that will reveal problems and deficiencies common to battlefield automated systems in general, and those unique to a particular system. The integration of separate analayses, comparisons among systems, description of problems and deficiencies, and conclusions and implications drawn from results are reported in Volume II of the final report of this project's first phase.

Because the analyses are oriented toward validating and enlarging a data base of problems and deficiencies in battlefield automated systems in general,

recommendations for changes to TCT or any other particular system are not a major purpose of the effort. However, the analytical technique described later lead naturally to recommendations for resolving problems and deficiencies described by the technique, and these recommendations are reproduced in the Appendix to this report. This issue is discussed more fully later in the report.

OVERVIEW OF THE SYSTEM

PURPOSE AND MAJOR FUNCTIONS

Purpose

The purpose of the TCT is to provide near-term, automated data processing support to combat and combat support commanders at all Army echelons. The TCT will improve information gathering and processing tasks supporting the commander's decision making processes. The system is designed for quick, easy use by functional personnel without special training as computer operators. Ultimately, the TCT will be coupled with the Tactical Computer System (TCS) as part of the Army Tactical Data System (ARTADS). The TCT (shown in Figure 1) and TCS (shown in Figure 2) are quite similar functionally, and their designs are consistent with each other. However, by providing greater storage capacity and increased communications capability, the TCS will add greatly to the data processing power provided by the TCT alone. Figures 3 and 4 show the TCT installed in the M577 armored command vehicle. A typical installation of TCS will be in the S-250 shelter shown in Figure 5.

Because the TCS has not yet been implemented, it could not be included in this analysis. Nonetheless, available information suggests that the findings presented here in regard to the TCT will be valid for the TCS also.

Major Functions

The TCT is a compact, modular, programmable, secure electronic device, developed to provide the following major functions, using standard Army tactical communications:

Figure 1. The Tactical Computer Terminal (TCT).

Figure 2. The Tactical Computer System (TCS).

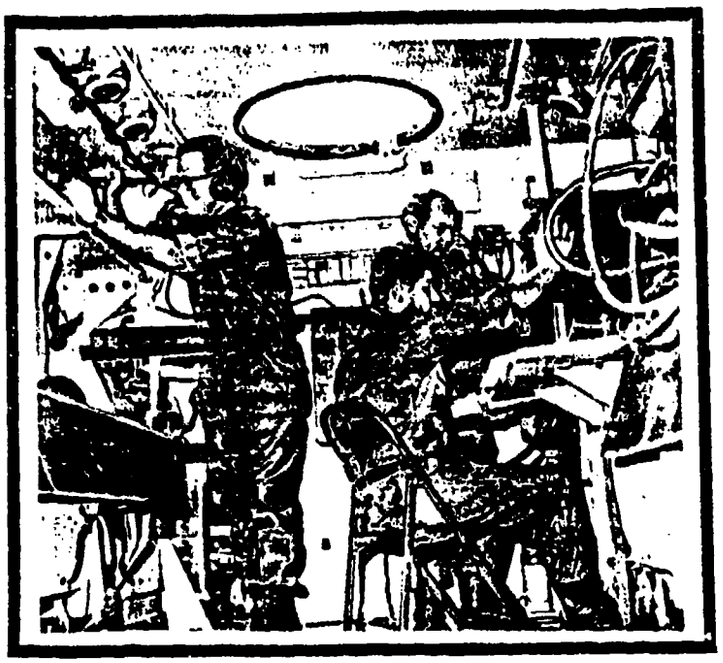

Figure 3. The TCT Installed in the M577 Armored Command Vehicle.

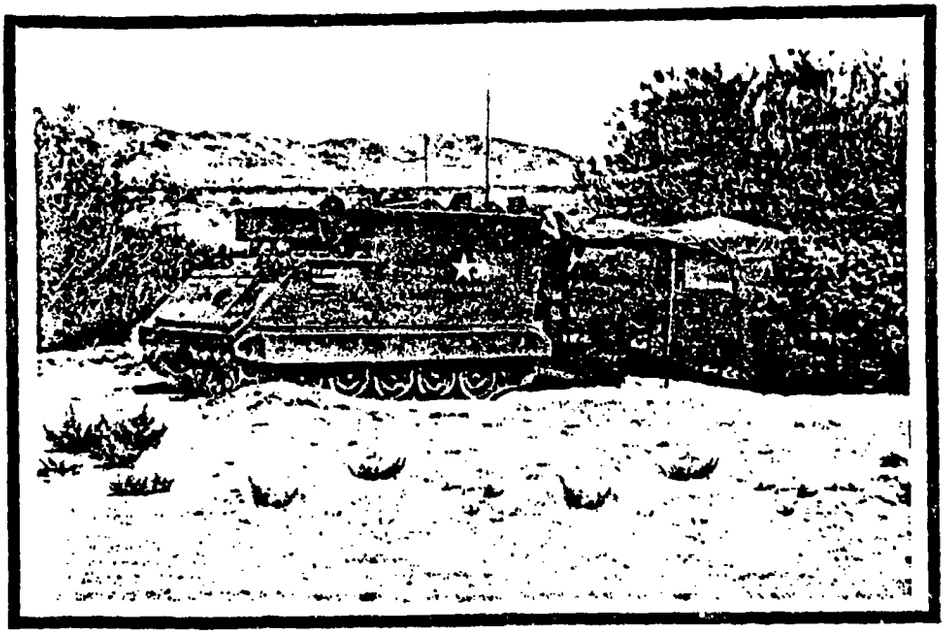

Figure 4. Remote Installation of the TCT.

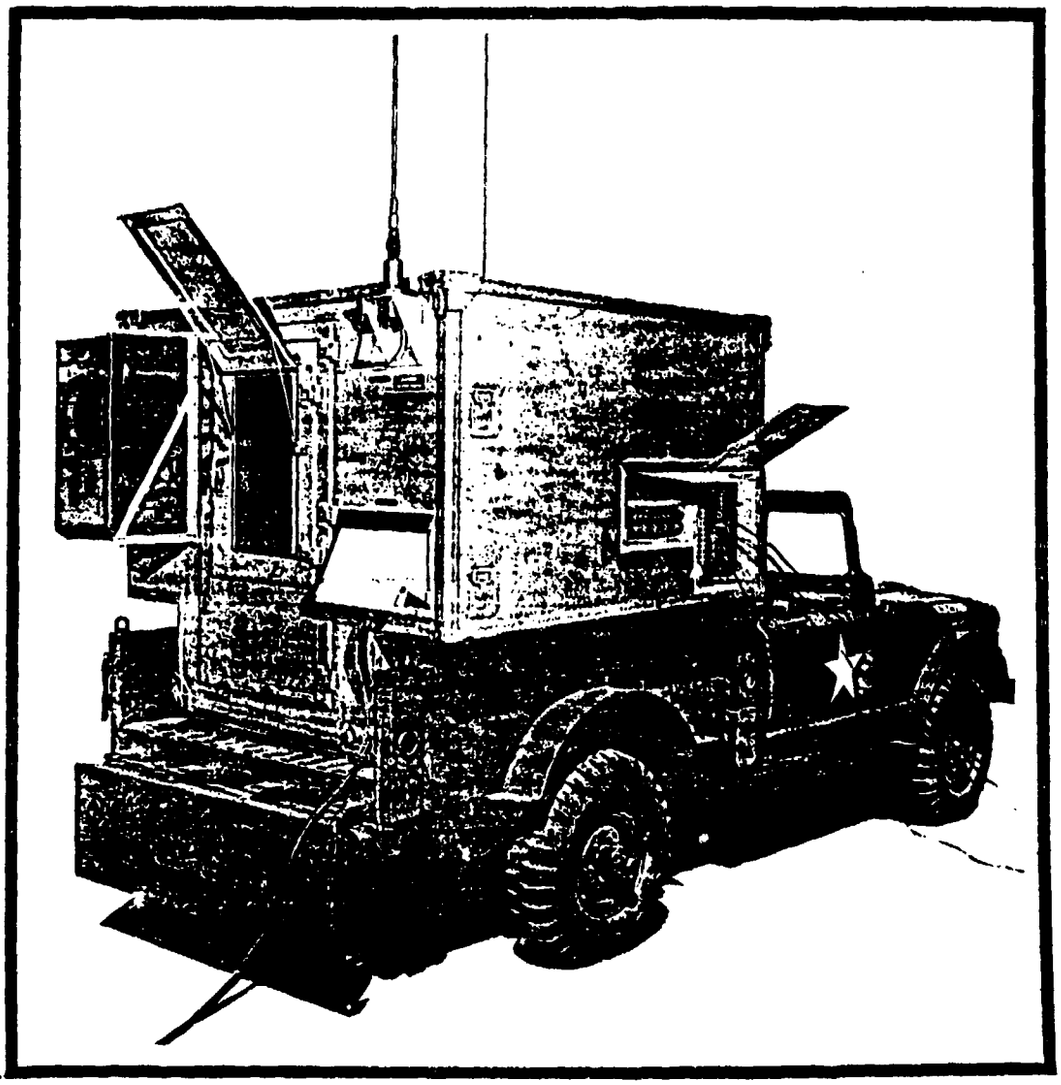

Figure 5. Typical Installation of the TCS in the S-250 Shelter.

a. Data entry

b. Message composition, editing and validation

c. Computation

d. Storage

e. Display printout

f. Digital message transmission and reception

In providing these functions, the TCT meets the following performance criteria:[1]

a. Performs as a node in a communication network.

b. Provides processing for the composition, edit, storage, retrieval, transmission, and reception of text messages.

c. Provides processing for the monitoring of digital and voice communication.

d. Provides application processing for user-dependent functions.

e. Provides system and operator error/fault notification through the use of alert messages.

f. Provides for the use of physical media (field wire) to communicate without the loss of data.

g. Relays messages from origin to the destination without error.

h. Operates with either the KG-13, KG-34, KY-57, KY-68, and KG-84 crypto devices.

i. Operates independently in the face of node, link, or other teleprocessing resource failures.

j. Interfaces with the user/operator via the TCT keyboard, plasma display, VFKs, printer, and other controls.

k. Message processing statistics are accurate to plus/minus one message in a total message population of 10,000 with 100% effectiveness.

---

[1] *Tactical Computer Terminal User Manual for Phase 1 of European Implementation Plan (Preliminary Draft)*. Glendale, California: Librascope Division of Singer, 1 August 1980, pp. 2-14.

l. Processes two simultaneously arriving messages (one each channel) without loss of any information.

m. Retrieves stored messages and stored application formats while in the text mode as follows:

   1. Application format - two seconds, 100% effectiveness.

   2. Stored messages - five seconds, 90% effectiveness.

n. Retrieves update message processing statistics in one second with 100% effectiveness.

o. Displays messages.

p. Prints messages at 1200 lines per minute and 85 characters per line.

q. Provides printout of diagnostic data and errors.

r. Accepts inputs of 50, 60, and 400 Hertz power and converts it to VDC when 28 VDC is not available.

RELEVANT HARDWARE ELEMENTS

TCT consists of the six modules shown in Figure 6: power supply, power distribution module, magnetic tape recorder-reproducer, line printer plotter,

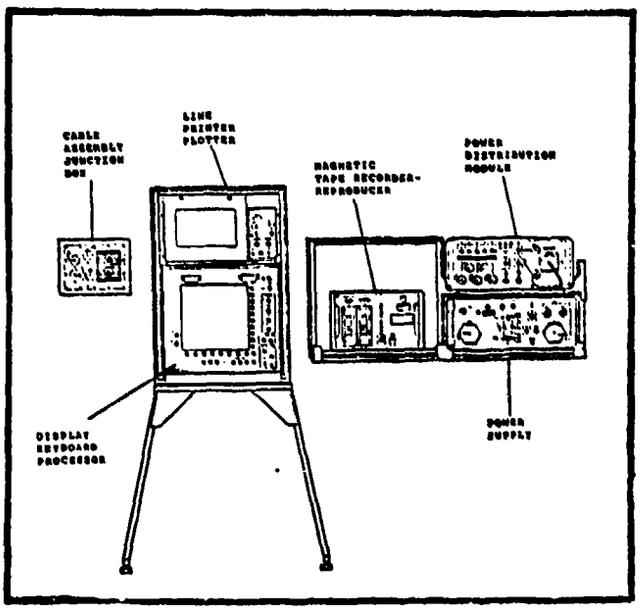

Figure 6. Components of the Tactical Computer Terminal (TCT). Extracted from user's manual cited in footnote 1.

display keyboard processor, and cable assembly junction. The component by which users/operators communicate with the system is the display keyboard processor, the component of greatest concern to this project (Figure 7). The display keyboard consists of two elements, the display panel and the

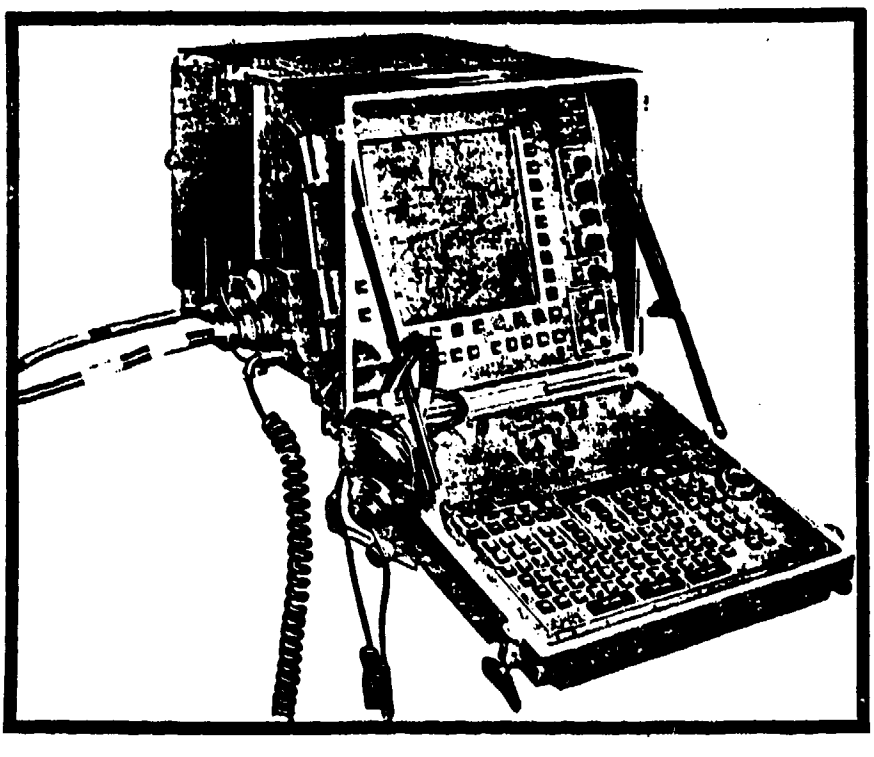

Figure 7. The TCT Display Keyboard Processor.

keyboard panel. All input and output is accomplished at the display keyboard processor via the keyboard; input and output are displayed on the plasma screen.

The Display Panel

The display panel (Figure 8) consists of a plasma display (Figure 9) and related controls and indicators. As shown in Figure 10, the screen is divided into four areas, one each for message display, prompt display, system level text, and display of variable function key legends.

Message Display Area. Four standard formats are used, described later in this report. The selected format appears in the top half of the plasma screen.

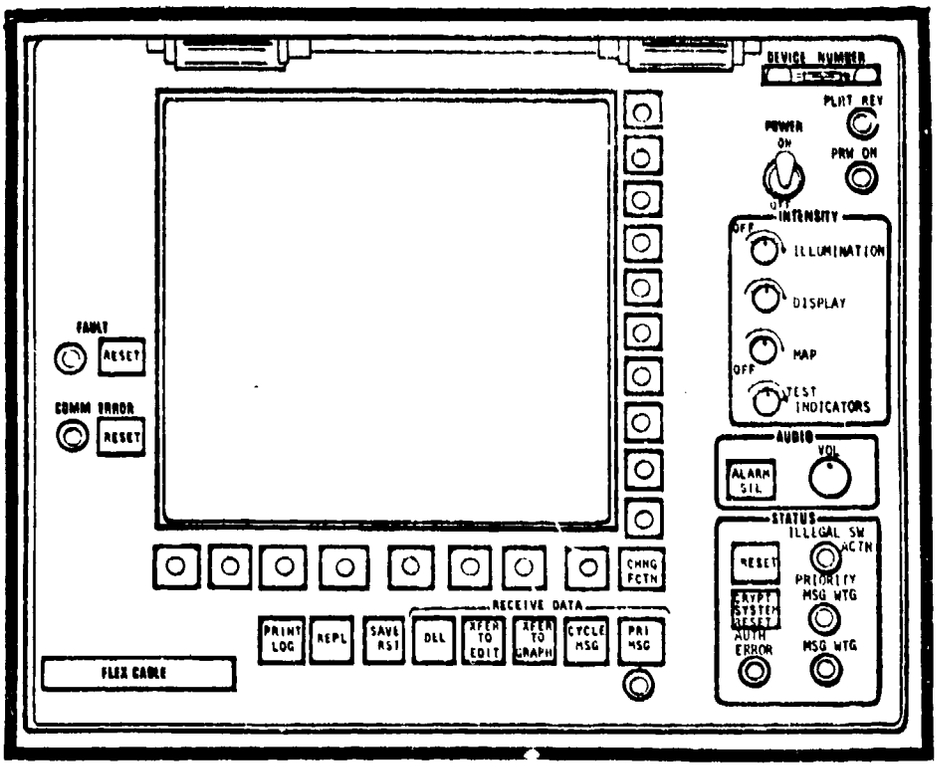

Figure 8. Display Controls and Indicator. Extracted from *Tactical Computer System User Manual: Preliminary Draft*, Singer: Librascope Division, Glendale, California, 1 July 1977.

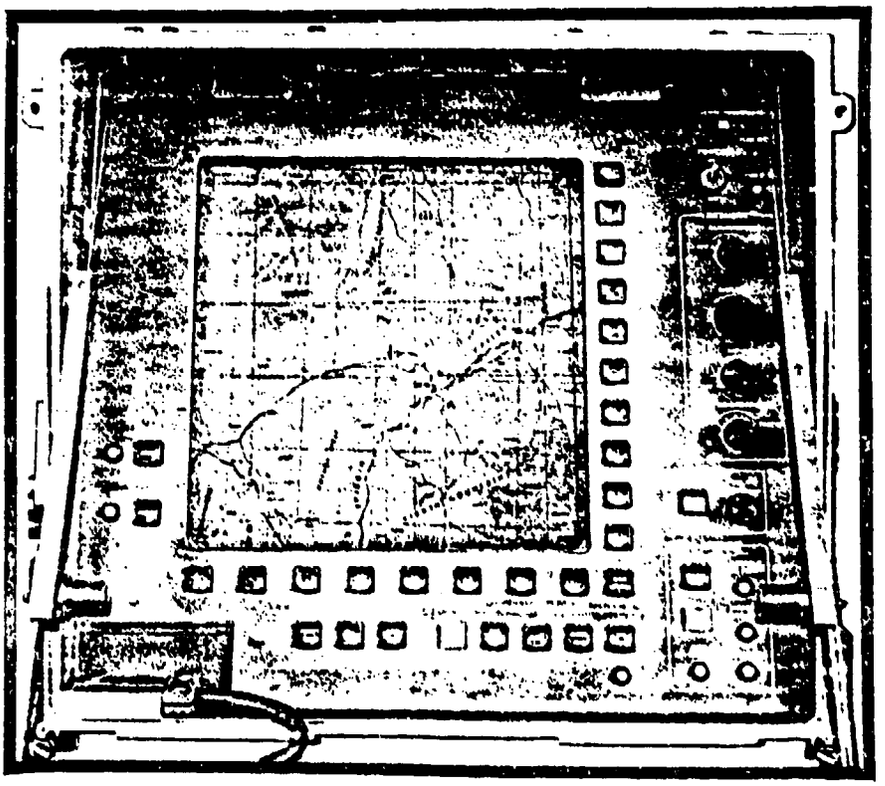

Figure 9. The Plasma Panel of the TCT Shown in the Graphics Mode.

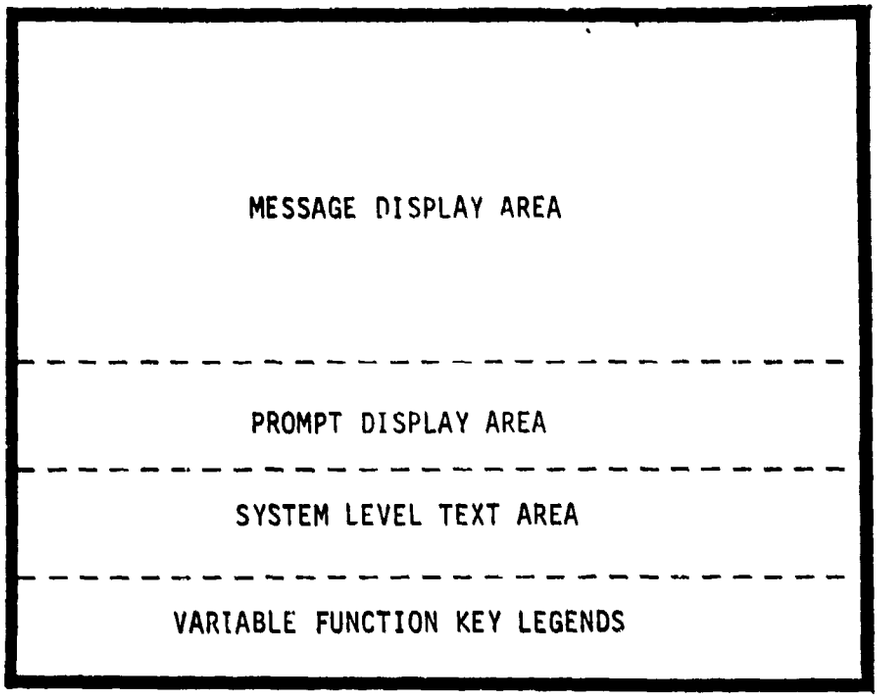

Figure 10. Plasma Screen Layout. Redrawn from user's manual cited in Footnote 1.

Prompt Message Area. Prompts are keyed to the various data elements contained in a message. Prompts associated with a message element are flagged by the cursor. Prompts are described later in the report.

System Level Text Area. Operator and system alerts provide instructional and status information. Specific alerts are described later in the report.

Variable Function Key Legends. As shown in Figure 8, two sets of variable function keys are located along the right side and bottom of the display screen. Functions of the switches change according to the mode of operation. Labels for the bottom row of switches are presented on the display screen.

The Keyboard

The TCT keyboard panel is shown in the bottom portion of Figure 11. The keyboard incorporates a standard QWERTY typewriter keyboard, a telephone-type numeric keypad, cursor controls, and fixed function keys and indicators. The keyboard and related controls permit entry of initialization data; composition of and change, correction, deletion, and addition to formatted and free

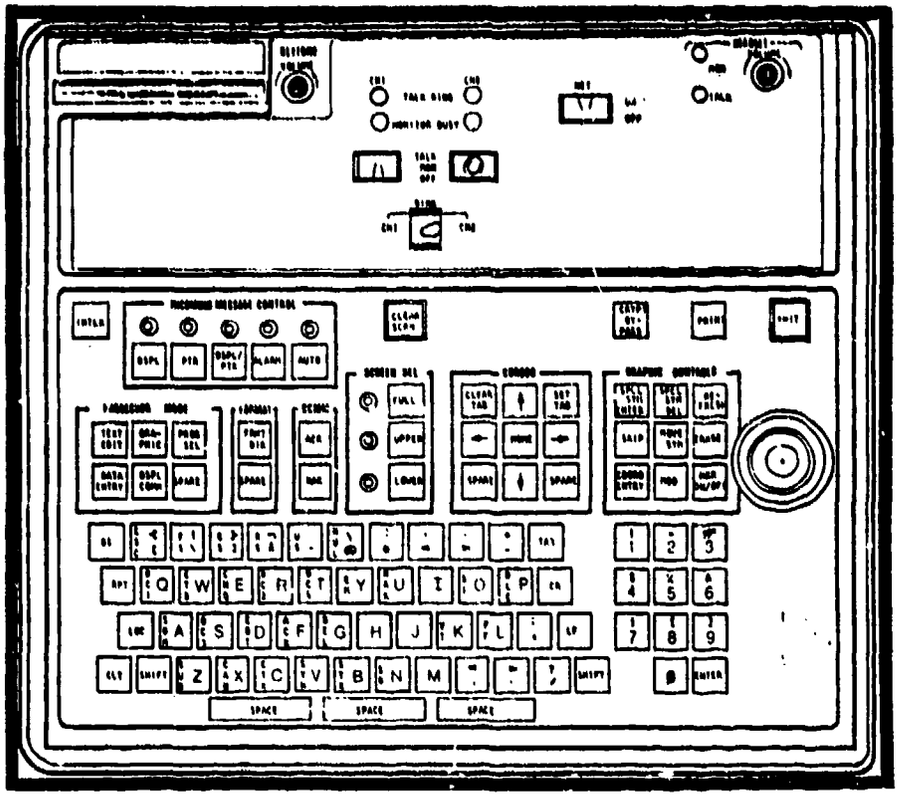

Figure 11. TCT Keyboard Controls and Indicator, Showing 2 Communications Channels. Redrawn from user's manuals cited in Footnote 1 and in Figure 2.

text messages; and message reception, queuing, validation, printing and transmission. Description of fixed function key operation is provided later in this report.

RELEVANT SOFTWARE ELEMENTS

Modes of Operation

Four modes of operation are available for user/operator selection:

a. Data entry mode (initialization). In this mode, the user/operator enters channel characteristics and other data to establish communication with other TCT terminals. When initialization is complete, another mode of operation can be selected for message processing.

b. Text edit mode (composition). The text edit mode permits composition or modification of messages. Empty message formats are obtained by selection from a message menu.

Prompts are provided for each message type, by message element area, to assist in message composition. Messages can be transmitted only while in the text edit mode.

c. Cycle message mode (display). The latest entered message (last in--first out) that has not been displayed is presented for review. This mode permits cycling through messages, and identification of the number of messages that have not been reviewed.

d. Replay message mode. In this mode, the oldest saved message (first in--first out) is recalled to the screen. Saved messages can be called up in a cyclical manner and are not destroyed until deleted. This replay mode can be entered from any other mode.

A set of operational functions interacts with the last three modes of operation to achieve full message processing capabilities. The functional options available with each of the operational modes are specified in Table 1.

Table 1

Modes of Operation/Functional Capabilities

Function	Mode of Operation		
	Text Edit	Cycle Message	Replay Message
Print the message	✓	✓	✓
Delete the message	✓	✓	✓
Clear the screen	✓	✓	✓
Save the record of selected text	✓	✓	
Transfer the message to edit		✓	✓
Transmit the message	✓		

Functions sometimes provide slightly different capabilities depending upon the operational mode. Appropriate system alerts associated with the mode-function combinations guide user/operator transactions.

In addition to fixed and variable function keys, TCT operations are conducted through manipulation of a set of formatted messages which are called up and completed primarily by a "fill in the blanks" approach. Pressing the DATA ENTRY fixed function key brings up page 1 of the initialization procedure, shown in Figure 12. Prompts are provided for each data field in the prompt area of the screen. For each data field, the prompts appear only when the

```
DTG:.....          AUTO PRINT WHEN:...../...../...../.....
OWN UNIT ID:.../.../.../.././.../.....          OWN NODAL ADDRESS:..

HARDWARE CONFIGURATION        CHANNEL #1              CHANNEL #2

          DEVICE:             .....                   .....
      MODULATION:             .....                   .....
       DATA RATE:             .....                   .....
       KEYLENGTH:             .....                   .....
    OUTPUT LEVEL:             .....                   .....
        3906 112:             .....                   .....
       STOP BITS:             .....                   .....

CHANNEL PROCESSING

         PROTOCOL:            .....                   .....
          EDC/TDC:            .....                   .....
            BLOCK:            .....                   .....
NUMBER OF RETRIES:            .....                   .....
   RETRY INTERVAL:            .....                   .....


SELECT <   > .
```

Figure 12. Page 1 of the Data Entry (Initialization) Format. NOTE: In this and succeeding Figures, dots show available character entry spaces, but do not appear on the screen. Reproduced from user's manual cited in Footnote 1.

cursor moves to that field. The cursor moves to the next field as soon as the information required to complete the field has been entered. The prompts available for the first four topics of the initialization procedure are presented in Table 2 as examples of TCT on-line prompts.

Table 2

Example of TCT On-Line Prompts for System Initialization.
Reproduced from user's manual cited in Footnote 1.

Topic	Prompt
DTG (Date Time Group): (Page 1)	ENTER DATE (2 DIGITS) FOLLOWED BY TIME (4 DIGITS) FOLLOWED BY ZONE (1 DIGIT) FOLLOWED BY MONTH (3 LETTERS) FOLLOWED BY YEAR (2 DIGITS).
AUTO PRINT WHEN:	ENTER (Y OR N) AUTO PRINT WHEN XMIT? AUTO PRINT WHEN RELAY? AUTO PRINT WHEN DELETE? AUTO PRINT WHEN RECEIVE?
OWN UNIT ID:	ENTER LOCAL NAME
OWN NODAL ADDRESS	ENTER YOUR ADDRESS

Once page 1 of the initialization process has been completed, page 2 of the process, shown in Figure 13, is called up by pressing a series of fixed and variable function keys. Once again, prompts are provided in the prompt

DESTINATION INFORMATION

UNIT ID	NUMBER OF MESSAGE SENT	NODAL ADDRESS	CHANNEL	RELAY	ALTERNATE NODAL ADDRESS
.../.../.../.././.../.....	...	..	..	.	
.../.../.../.././.../.....	...	..	..	.	..
.../.../.../.././.../.....	...	..	..	.	..
.../.../.../.././.../.....	...	..	..	.	..
.../.../.../.././.../.....	...	..	..	.	..
.../.../.../.././.../.....	...	..	..	.	..
.../.../.../.././.../.....	...	..	..	.	..
.../.../.../.././.../.....	...	..	..	.	..
.../.../.../.././.../.....	...	..	..	.	..
.../.../.../.././.../.....	...	..	..	.	..
.../.../.../.././.../.....	...	..	..	.	..
.../.../.../.././.../.....	...	..	..	.	..
.../.../.../.././.../.....	...	..	..	.	..
.../.../.../.././.../.....	...	..	..	.	..
.../.../.../.././.../.....	...	..	..	.	..
.../.../.../.././.../.....	...	..	..	.	

SELECT < >

Figure 13. Page 2 of the data entry (initialization) format. Reproduced from user's manual cited in Footnote 1.

area of the screen for all these topics. With completion of system initialization, another operational mode can be called up.

Other TCT operations are available through a message format menu, accessed by depressing the FRMT DIR (format directory) fixed function key. The format menu provides the following four message formats: Situation Report (SITREP) Message (Figure 14); Rapid Reporting of Significant Tactical Activities (SPOT) Message (Figure 15); Unit Task Organization (UTO) Message (Figure 16); and a Free Text (FREE) Message (Figure 17).

```
TO-NODE: @@@@@@      MSG:SITREP      SCTY:.....      PREC:.....
TRANS-TIME:.....  GRID-ZONE:...
TO:   .../.../.../../../.../.....       EFF-TIME:.....
FROM: .../.../.../../../.../.....       MISSION:.....
MAIN CP/PAD:...../.....          TAC CP/PAC:...../.....
COORD PT:.....-.....-.....-.....-.....
FLT:.....-.....-.....-.....-.....-.....
    .....-.....-.....-.....-.....-.....
ENEMY ACTIONS/INTENSITY:.....
STATUS:
CIESEL AVAIL:...%     MOGAS AVAIL:...%      COMMO:      RADS:....
                EQUIP   CREWS   AMMO                    EQUIP   CREWS  AMMO
ITEM:           AVAIL   AVAIL   AVAIL       ITEM:       AVAIL   AVAIL  AVAIL
ATKHEL            ...     ...     ...%      ADA SYSTEM    ...     ...    ...%
UH1-M56           ...     ...     ...%      .....         ...     ...    ...%
CH47              ...     ...     ...%      .....         ...     ...    ...%
TOW               ...     ...     ...%      .....         ...     ...    ...%
DRAGON            ...     ...     ...%      .....         ...     ...    ...%
M60A1             ...     ...     ...%      .....         ...     ...    ...%
M60A2             ...     ...     ...%      .....         ...     ...    ...%
APC               ...     ...     ...%      .....         ...     ...    ...%

REMARKS:.....
.....*EOT*
```

Figure 14. SITREP message format. Reproduced from user's manual cited in Footnote 1.

```
TO-NODE:..@@@@@@      MSG:SPOT      SCTY:.....      PREC:.....
TRANS-TIME:.....  GRID-ZONE:...
TO:   .../.../.../../../.../.....       EFF-TIME:.....
FROM: .../.../.../../../.../.....
WHERE:.....-.....
WHO,WHAT,WHY:
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
SOURCE:.....
SENDERS EVAL:..
REMARKS:.....
.....*ETO*
```

Figure 15. SPOT message format. Reproduced from user's manual cited in Footnote 1.

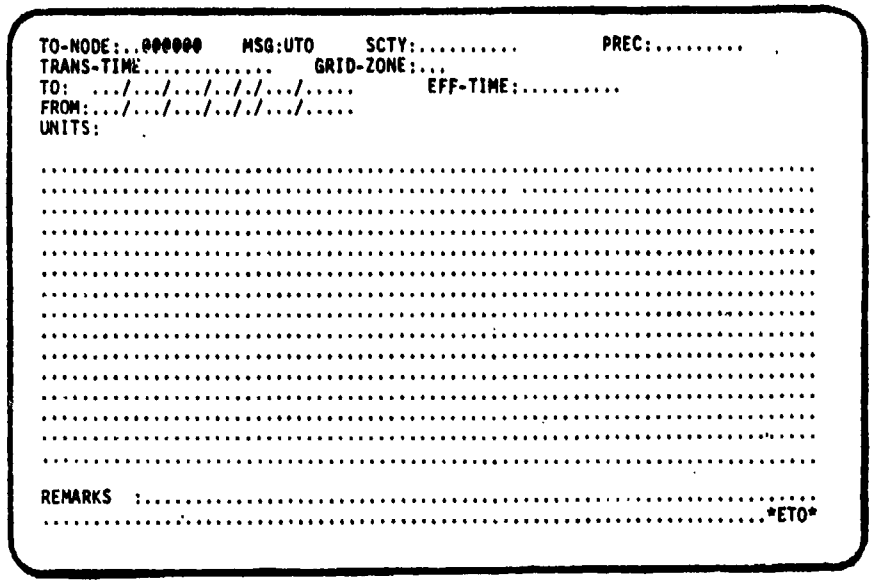

Figure 16. UTO message format. Reproduced from user's manual cited in Footnote 1.

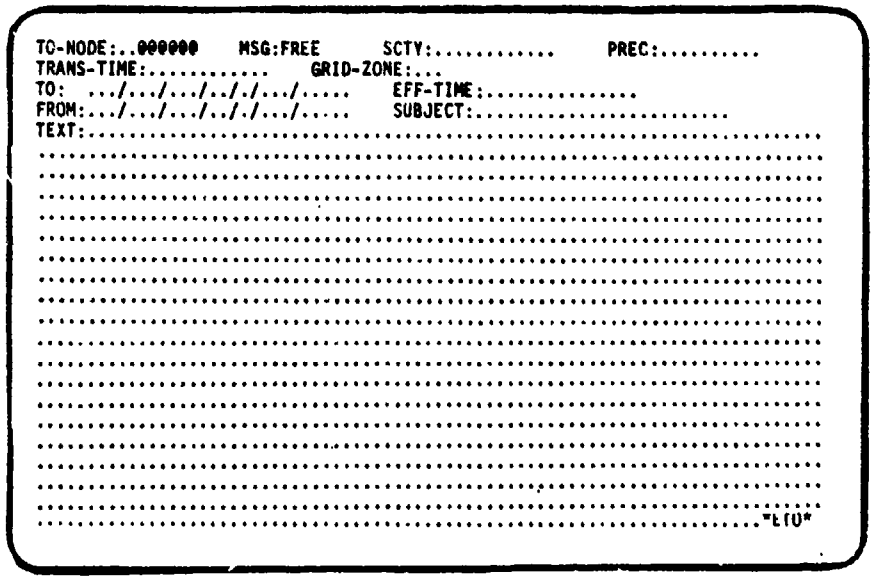

Figure 17. FREE message format. Reproduced from user's manual cited in Footnote 1.

As shown for the system initialization format in Table 2, each of the topic areas of the four standard message formats is supported by on-line prompts which appear in the prompt area of the display panel. Table 3 shows a sample of prompts for the SITREP message.

Table 3

Sample On-Line Prompts for SITREP Message Format.
Reproduced from user's manual cited in Footnote 1.

Topic	Prompt
TO-NODE	ENTER THE NUMBER (00-99) THAT IDENTIFIES THE TERMINAL TO RECEIVE THE MESSAGE.
SCTY	(ENTER THE SECURITY CLASSIFICATION) 01 UNCLASSIFIED 02 CONFIDENTIAL 03 NATO CONF 04 SECRET 05 NATO SECRET 06 TOP SECRET 07 COSMIC TS 08 ATOMAL TS
PREC	(ENTER THE COMMUNICATIONS PRECEDENCE) 01 ROUTINE 02 PRIORITY 03 IMMEDIATE 04 FLASH
TRANS-TIME	ENTER DATE (2 DIGITS) FOLLOWED BY TIME (4 DIGITS) FOLLOWED BY ZONE (1 LETTER) FOLLOWED BY MONTH (3 LETTERS) FOLLOWED BY YEAR (2 DIGITS), THIS REPORT WILL BE TRANSMITTED AT APPROX. (EXAMPLE:051345ZFEB80)
GRID-ZONE	ENTER THE GRID ZONE DESIGNATION OF YOUR LOCATION. (EXAMPLE:32U)

Format Composition Rules

A common set of symbols is used in message construction for all message types. These symbols delimit topic areas, divide data fields into subfields, identify characters automatically provided by the software, etc. Table 4 presents the symbol set.

Table 4

Delimiting Symbols Used in the TCT Message Formats

Symbol	Definition
Colon (:)	Denotes the end of the field name and the beginning of the data field.
Space ( )	Indicates spaces, fields, or lines that are not used.
Slash (/)	Separates individual items of a multiple entry data field with unlike code characteristics and data items.
Dash (-)	Separates individual items of a multiple entry data field with identical code characteristics and similar data items.
At (@)	Denotes characters within entries that are automatically provided by the software.
Double brackets ([[]])	Used in the prompt area of the screen to identify the topic of the prompt.
Parentheses (" ")	Used in the prompt area of the screen to enclose a precise requirement (e.g., number of digits to be entered) or to identify an example.

ANALYSIS OF TRANSACTION FEATURES

As with other in-depth analyses in this series, the TCT was analyzed by means of two primary methods: document reviews and interviews with subject matter experts. In both methods, analysts recorded their observations using a Transaction Feature Analysis technique developed for this purpose. Table 5 describes the technique.

The Transaction Feature Analysis technique is useful in guiding the analyst to detect and describe desirable, as well as undesirable, design features affecting user/operator transactions. In the case of desirable features, the technique can capture lessons learned from one system that will be relevant to other, perhaps future, systems. In this way, the technique can help to overcome the problem of information transfer among systems. Of course, when describing a desirable feature, the analyst enters a uniform notation for Recommended Resolution: "None required."

Table 5

Description of the Transaction Feature Analysis Technique

Transaction Feature. Describes the type of transaction being analyzed.
Description. Describes how the feature works in system operations. The description includes a specific example of the feature in straightforward, operational terms.
Behavioral Implication. Describes the feature's impact on the user's/operator's performance. The description includes what the individual must do--and must not do--in using the feature. It also includes requirements imposed upon the user/operator in terms of memory burden, error likelihood, skill requirements, and/or other performance-related issues.
Transactional Implication. Describes the feature's effect on the system's processing operations. The description includes issues such as the system's ability to detect errors, its error handling procedures, and/or the time required to complete transactions.
Consequences. Describes the feature's impact on overall system performance. Here, the analyst predicts the answers to questions such as the following: What effect does the feature have on the accuracy and timeliness of the data base? What effect does the feature have on the quantity and quality of output? Will the commander's picture of the battlefield be enhanced or distorted? Will targets be fired more quickly, or lost?
Recommended Resolution. Describes specific, detailed remedial action. These recommendations include changes to hardware, software, or procedures that will improve system performance

Transaction features analyzed with the technique are organized according to the categories shown in Table 6. Results of the analyses are discussed in the same order; the individual analyses are presented in the Appendix.

Table 6

Categories of Design Features Affecting User/Operator Transactions with Battlefield Automated Systems

1. CONTROL METHODS

   1.1 Command Languages
   1.2 Menus
   1.3 Function Keys
   1.4 Hybrid Methods
   1.5 Prompts/HELPS

2. DISPLAY FORMAT

   2.1 Fixed Alphanumeric Displays
   2.2 Variable-Length Alphanumeric Displays
   2.3 Graphic Displays
   2.4 Highlighting

3. DATA ENTRY AND HANDLING

   3.1 Information on Legal Entries
   3.2 Unburdening of Input
   3.3 Interrupts and Work Recovery
   3.4 Manipulating Stored Data

4. MESSAGE COMPOSITION AIDS

   4.1 System Design Features
   4.2 Format for Alphanumeric Messages
   4.3 Graphic Messages

5. DATA RETRIEVAL ASSISTANCE

   5.1 Query Method
   5.2 Query Structure

6. GLOSSARIES

   6.1 Standard Terms
   6.2 Character Sets and Labels
   6.3 Glossary Availability and Use
   6.4 Abbreviation and Coding

7. ERROR HANDLING

   7.1 Prevention
   7.2 Detection
   7.3 Feedback
   7.4 Correction/Recovery

8. USER/OPERATOR CONFIGURATION

   8.1 Operator(s) Only
   8.2 Operator(s) and User(s)
   8.3 Combined User/Operator
   8.4 User and Operator Chains

1. CONTROL METHODS

1.1 Command Language

For purposes of this effort, command language may be defined as the syntax and vocabulary of system control instructions that are entered into the computer as statements composed of words, abbreviations, or codes (commands) and appropriate parameters. Most typically, such statements are entered by typing at a keyboard. Under this definition, the TCT does not incorporate a command language. System control instructions are entered into the computer via menus and function keys.

1.2 Menus

The TCT makes extensive use of menus. The message format type is selected from a menu which is accessed by depression of the FRMT DIR (format directory) fixed function key. The message format is displayed on the upper portion of the display screen. As the cursor is moved from data field to data field, a menu of responses appropriate to the data field appears in the prompt area of the screen. Even non-numeric data content is entered by input of numeric codes. For numeric data, the range of appropriate numbers is identified.

The availability, comprehensiveness, and clarity of the TCT menus contribute greatly to user/operator ease of operation. In conducting the transaction feature analysis, some ways for improving the TCT menus were found. Suggestions for greater consistency in presentation (presenting only those responses that are legal in hierarchical menus, for example) are offered.

1.3 Function Keys

Function keys are employed extensively in the TCT. Two sets of variable (programmable) function keys are located along the right side and bottom of the display screen. The functions of these keys vary with the mode of operation and are identified by labels which appear on the display screen. The labels and functions of the variable function keys are presented in Table 7.

The TCT also makes extensive use of fixed function keys on both the display panel and the keyboard panel. The display panel fixed function keys are

described in Table 8. The fixed function keys on the keyboard panel are presented in Table 9.

Table 7

Variable (Programmable) Keys for the TCT Display Panel

Label	Operation
	DATA ENTRY MODE
NEXT TOPIC	Activation moves the cursor forward to the next topic (data field).
PREV TOPIC	Activation moves the cursor backward to the last topic (data field).
	TEXT EDIT MODE
NEXT TOPIC	Activation moves the cursor forward to the next topic (data field).
PREV TOPIC	Activation moves the cursor backward to the last topic (data field).
NEXT LINE	Activation moves the cursor forward to the beginning of the next line.
PREV ENTRY	Activation moves the cursor backward to the beginning of the last entry.

Table 8

Fixed Function Keys for the TCT Display Panel

Control/Indicator	Label	Operation
Alarm silencer	ALARM SIL	When pressed, silences the audio alarm.
Illegal switch action	ILLEGAL SW ACTION	Lights when wrong order of switch actions occurs; is extinguished when RESET is pressed.
Priority message waiting	PRIORITY MSG WTG	Lights when priority message is waiting in the message queue.
Message waiting	MSG WTG	Lights when nonpriority message is waiting in the message queue.
Reset	RESET	Lights when ILLEGAL SW ACTION or AUTH ERROR light comes on. When pressed, resets (extinguishes) the lights.
Authentication error	AUTH ERROR	Lights when an authentication error is detected, i.e., a received authentication code does not correspond to the proper authentication code. Is extinguished when the RESET switch is pressed.

Table 8 (Continued

Control/Indicator	Label	Operation
Crypto override	CRYPTO OVER RIDE	If pressed, and XMIT switch pressed simultaneously, will bypass KG-31.
Fault (LED) and RESET	FAULT RESET	Indicator light is lit when the system has a fault; flashes when a new fault has occurred. Pressing the RESET switch turns off the LED indicator, prints the fault list on the printer, and removes the fault message from the display screen.
COMM ERROR (LED) and RESET switch	COMM ERROR RESET	Indicator light is lit when the system detects an error. Pressing the RESET switch turns off the LED indicator and removes the error message from the display screen.
Change function	CHNG FCTN	When pressed, this switch will change the legends of the programmable switches (displayed on the screen) in a predetermined fashion.
Priority message	PRI MSG	Lights when a message is added to the receive queue that has a higher priority than any message in the queue at that time. Pressing the switch places the first page of the highest priority message on the receive display screen.
Cycle message	CYCLE MSG	When pressed, calls up the first page of the next message in the receive queue.
Transfer to graphic mode	XFER TO GRAPH	When pressed, transfers message being displayed to the graphic mode.
Display next page of multi-page message	PAGE	When pressed, presents the next page of a multi-page message.
Transfer to edit	XFR TO EDIT	When pressed, purges the contents of the message on the receive display to the compose/edit display.
Delete the message	DEL	When pressed, this switch transfers the received message out of the receive queue. The message is purged and is no longer available. The DEL switch is interlocked with the INTLK switch on the keyboard.
Save the message	SAVE RST	When pressed, this switch saves the contents of the message on the compose/edit display and restores the previously saved message to the display screen.
Replace the message	REPL	When pressed, this switch takes the contents of the message currently being displayed on the compose/edit portion of the screen and places it in the message receive queue.
Print the log	PRINT LOG	When pressed, this switch prints the entire log of received and transmitted messages since the last print.

Table 9

Fixed Function Keys for the TCT Keyboard Panel

Control/Indicator	Label	Operation
Incoming Message Control		
Display the message	DSPL	When activated, places all received incoming messages on the display when any of the PAGE, CYCLE, or PRI MSG switches on the display panel is activated.
Print the message	PTR	When activated, places all received incoming messages on the printer when any of the PAGE, CYCLE, or PRI MSG switches on the display panel is activated.
Display and print the message	DSPL/PTR	When activated, places all received incoming messages on both the plasma display and the printer when any of the PAGE, CYCLE, and PRI MSG switches is activated.
Alarm announcing incoming message	ALARM	When activated, sounds an alarm when an incoming message is received. The alarm sounds after the message reaches the received queue.
Automatic message routing	AUTO	When activated, routes all incoming messages--by message type--to the appropriate output device.
Transmission Control		
Transmit uncoded message	CRYPT BY-PASS	When activated, allows transmission of an uncoded message.
Acknowledge message	ACK	Activation transmits a manual acknowledge message.
Non-acknowledge message	NAK	Activation transmits a manual non-acknowledge message.
Print the message	PRINT	Activation initiates transmission of a message to the printer for a hard copy print of the message as a function of the SCREEN SEL key which is activated.
Screen Select		
Full screen	FULL	When activated along with the PRINT key, allows the upper cursor to move over the first 28 lines of the display screen.
Upper screen	UPPER	When activated along with the PRINT key, allows the upper cursor to move over the first 14 lines of the display screen.
Lower screen	LOWER	When activated along with the PRINT key allows the cursor to move over lines 15 through 40 of the display screen.
Clear the screen	CLEAR SCRN	Activation clears the screen of a function of the screen select identification.

Table 9 (Continued)

Control/Indicator	Label	Operation
Interlock Control		
Interlock to other display and keyboard controls	INTLK	When pressed and held down, allows activation of controls associated with processor mode and format selection controls on the keyboard panel and the data deletion control on the display panel.
Processor Mode Control		
Text edit mode select	TEXT EDIT	When activated along with the INTLK key displays the variable switch legends associated with the text editing mode and enables the text editing mode.
Graphic mode select	GRAPHIC	When activated along with the INTLK key, allows use of the plasma display in the graphics mode and of the special symbol library.
Program select	PROG SEL	When activated along with the INTLK key, allows selection of program associated with the variable (programmable) function switches.
Data entry mode select	DATA ENTRY	When activated along with the INTLK key, displays the variable switch legends associated with the data entry mode and enables the data entry mode.
Display voice communication assignments	DSPL COMM	When activated along with the INTLK key, displays the current voice communication channel/network assignments.
Format Control		
Format selection	FRMT DIR	Activation displays the format directory (menu) for fixed format messages.
Cursor Control		
Set the tab	SET TAB	Activation sets the tab at the location of the cursor along an 80 character line.
Clear the tab set	CLEAR TAB	Activation clears the tab set at a particular location along an 80 character line after activation of the tab.
Move the cursor up	↑	Each activation repositions the cursor one line above the cursor line.
Move the cursor down	↓	Each activation repositions the cursor one line below the cursor line.
Move the cursor left	←	Each activation repositions the cursor to the left one alphanumeric position.
Move the cursor right	→	Each activation repositions the cursor to the right one alphanumeric position.

Table 9 (Continued)

Control/Indicator	Label	Operation
Home the cursor	HOME	Activation resets the cursor to the first valid entry position of the first line on the display screen as a function of the SCREEN SEL key which is activated.
Graphic Controls		
Special symbol entry	SPCL SYM ENTER	Activation enters a special symbol into the memory buffer. The mnemonic for the symbol is then typed in using the alphanumeric keyboard.
Special symbol deletion	SPCL SYM DEL	Activation deletes a special symbol from the memory buffer.
Refresh the screen	REFRESH	Activation returns a graphic to the display screen.
Change graphics element position	SKIP	Activation allows the creation of unconnected lines or the marker to span a line or character string. Requires concurrent activation of either the MOD or COORD ENTRY switch.
Move a graphics symbol	MOVE SYM	When activated along with the MOD switch, relocates the symbol to a new position on the display screen.
Symbol, vector element or character string delete	ERASE	When activated along with the MOD switch, deletes the entire symbol from the display screen. When activated along with both the MOD and SKIP switches, deletes a single vector element or character string.
Start/stop entry of vector element	COORD ENTRY	Pressing indicates the beginning or end of a line on the display screen.
Interlock to other graphics controls	MOD	Activation causes the software to "hook" a symbol near the marker, allowing use of SKIP, ERASE, or MOVE SYM switches.
Enter or delete a marker	MKR ON/OFF	Activation causes a marker to appear on the display screen.
Keyboard		
Enter Alpha characters	(QWERTY ALPHA CHARACTERS)	Activation of key enters a letter
Enter numerics	(NUMERIC KEY PAD)	Activation of key enters a number.
Advance a space	SPACE	Each activation spaces one character width.
Enter date	ENTER	Activation allows entry of alphanumeric data as a function of mode selection.

1.4 Hybrid Methods

Hybrid methods combine the use of two control methods within a given transaction. For TCT, the FRMT DIR key and subsequent format selection represents a hybrid method in that:

a. Activation of the FRMT DIR fixed function key displays a menu of message formats.

b. The message format selection is accomplished by keying in the message format code via the keyboard.

No problems or deficiencies were observed in the hybrid methods employed with the TCT.

1.5 Prompts/HELPS

Prompts are plentiful in TCT. That is, the menus provided for each data field for each message type (as described above, under "Menus") serve as a prompt to the user/operator. The availability of menus for the formatted messages resulted in considerable attention being given to the design and utility of the menus/prompts. While the transaction feature analysis provides recommendations for a variety of possible improvements to these menus/prompts, for the most part these recommendations result in improved ease of system operation and do not address conditions which are likely to have severe operational or tactical consequences. Recommendations are for improvements such as: (a) utilization of hierarchical menus/prompts for greater sensitivity of presented data and (b) emphasis on language meaningful to the user/operator rather than on technical precision.

HELPS are software routines which allow the user/operator to break out of the normal procedure for a transaction, obtain assistance regarding definitions of terms or values of legal entries, and then return to the point at which the normal procedure was interrupted. TCT provides HELPS in the form of operator and system alerts displayed on the plasma screen. Table 10 describes operator and system alerts. Operator alerts provide direct instructions to the user/operator regarding some sources of action. System alerts are more cautionary, or identify courses of action dependent upon other system indicators.

Table 10

Plasma Screen Alerts

Alert	Operator Response
OPERATOR ALERT AREA	
PUSH FORMAT DIRECTORY KEY.	Press FRMT DIR key to display format directory, then select desired format.
SELECT A MODE.	Press CYCLE MSG, DATA ENTRY, TEXT EDIT, OR REPL key, as desired.
INVALID ENTRY. TRY AGAIN.	Press proper key.
WAIT. PUSH XMIT AGAIN.	Wait 30 seconds, then press XMIT key.
THE SAVE AREA IS EMPTY.	There are no messages in the save area. No response is required.
THE SAVE AREA IS FULL.	Make decision to either save existing messages or to delete one or more. To delete, press REPL key, DEL key, then repeat procedure as necessary to delete additional saved messages.
SYSTEM ALERT AREA	
RCV DATA AREA ALMOST FULL.	Room left for only three or less messages in MSG TO REVIEW area. Press CYCLE MSG key, review message on plasma screen, and press DEL key. Repeat above procedure as necessary to reduce message load.
TRANSMIT FAILED ON CHAN 1.	Do the following on channel 1: (1) Attempt transmission twice more by pressing XMIT key. (2) Check initialization data by pressing DATA ENTRY for page 1 and then press CHNG FCTN key for page 2. Correct data as necessary. (3) Make voice communication with receiving station to check if trouble is with that station.
TRANSMIT FAILED ON CHAN 2.	Same procedure as for TRANSMIT FAILED ON CHAN 1, but do for channel 2.
PRINTER PAPER LOW	Add paper to printer.
CHECK PRINTER PAPER.	Check printer for paper jam. Correct.
CPU FAULT	Processor failure. Do the following: (1) Press CYCLE MSG key and then DEL key consecutively until all messages are printed. (2) Set display keyboard processor POWER switch at OFF. (3) Replace A1A28 card in accordance with DEP TM 11-7440-303-12.
INITIALIZATION COMPLETE	All initialization data has been recorded in the TCT.

2. DISPLAY FORMAT

2.1 Fixed Alphanumeric Displays

TCT operates on a set of four formatted messages shown in Figures 8, 9, 10, and 11. Even the initialization procedure is accomplished via a two-page formatted message (Figures 6 and 7). The TCT message formats are well designed in that they are not cumbersome either in size or density. Data fields containing multiple pieces of information of fixed length (e.g., TO, FROM) are appropriately sectioned off to guide the user/operator in data entry. For other alphanumeric fields of fixed length (e.g., TRANS-TIME), the prompts are such that size and data entry type (alpha versus numeric--see Table 3) are clearly indicated to the user/operator. The SITREP message format, with the exception of the REMARKS section, is a completely fixed format fully supported by prompts provided in the form of menus.

2.2 Variable-Length Alphanumeric Displays

Each of the four TCT message formats permits entry of some variable length alphanumeric data. As indicated above, SITREP is almost totally formatted but the SPOT, UTO, and FREE message formats are very nearly open in message construction. The SPOT and UTO formats restrict the types of information that can be entered but the FREE message format imposes no such restriction--within the reasonableness of the content to the unit's mission.

2.3 Graphic Displays

A graphic display capability is incorporated into TCT. Limited description of how the keyboard controls are manipulated to provide and modify graphics is presented in Table 9. However, graphics were not considered part of the Phase 1 implementation of TCT and our knowledge is limited to a brief discussion of the graphic controls. No transaction feature analysis was possible. Future transaction feature analyses will be directed to TCT graphics capabilities.

2.4 Highlighting

We have no information regarding highlighting on TCT.

3. DATA ENTRY ASSISTANCE

3.1 Information on Legal Entries

The TCT menus provide the legal entries to the user/operator. There are some instances, however, when greater selectivity of the data presented on legal entries (e.g., channel characteristics specifications) would greatly enhance system operability. Suggestions are presented in the Appendix for improving presentation and information on when use of specific function keys are permitted. The use of certain fixed function keys and not others varies logically by mode of operation. However, the versatility of TCT operation could permit some confusion to inexperienced users/operators. Identification of legal FFKs could eliminate potential user/operator confusion.

3.2 Unburdening of Input

TCT has adapted procedures which reduce the user/operator burden. One example is the capability to enter selected menu items by a simple number code. This feature is provided consistently for non-numeric data entries. The transaction feature analysis resulted in suggestions for additional features which would contribute to the unburdening of input. Suggestions have to do with providing a menu listing only those units with which a given unit communicates and strategies for more automatic entry of date, clock time, zone, month and year.

3.3 Interrupts and Work Recovery

The analysis of TCT revealed little about this topic. One area of concern is that of retransmission of a message which could not be transmitted initially. Another area of concern is that of attending to the necessity for retransmission of the message when message traffic is heavy and/or critical. Two suggestions for assisting the user/operator in timely retransmission are provided.

4. MESSAGE COMPOSITION AIDS

4.1 System Design Features

To date, only minimal aspects of the system design pose user/operator problems. One of these has to do with the lack of close visual feedback associated with data entry. The current design of the display screen separates the message and prompt areas. Shifting between these two areas of the screen for verification of correct entry of data during periods of heavy and/or critical message traffic could cause undue user/operator eye fatigue. Another system design feature, the requirement to provide identical hardware configuration specification at system initialization, could be eliminated by provision of default initialization.

4.2 Format for Alphanumeric Messages

The message formats have been previously discussed under the Display Format area of this section of the report. No features relevant to the message format proper requiring Transaction Feature Analysis were observed.

4.3 Graphic Messages

As noted above, a graphics capability is planned but has not yet been implemented.

5. DATA RETRIEVAL ASSISTANCE

The information available to date concerning TCT has dealt more specifically with data entry and transmission then with data retrieval. Data query methods are not implemented within TCT.

6. GLOSSARIES

Standard terms, character sets and labels, glossaries, and abbreviation and coding utilized in TCT standard message formats are presented to the user/operator via the menus/prompts. Some suggestions for modification of the

presentation and utilization of these as well as for system design and software modifications which affect these aspects of TCT operation have already been discussed. For the limited view of TCT operation available to us from the Phase 1 user's manual, design and on-line availability of standard terms, character sets and labels, etc., are adequate to support user/operator needs.

7. ERROR HANDLING

7.1 Error Prevention

No specific routines for error prevention have been identified. As noted above, the availability of legal data entry items via the menus contributes directly to error prevention.

7.2 Error Detection

Only minimal detection of message entry or system operation error is provided on TCT. The operator alerts which appear on the plasma screen provide indications of invalid entry and identify certain function key operations which should be performed. But both operator and system alerts are more precisely "alerts" than error detection in that they advise about status or what needs to be done.

7.3 Error Feedback

No specific diagnostic or instructional information for error correction is provided on TCT. Invalid entry of data receives only an "Invalid Entry. Try Again" message. System performance could be improved by providing specific information about the nature of the error, and by offering advice online regarding appropriate error correction procedures.

8. USER/OPERATOR CONFIGURATION

Little information has been available regarding TCT user/operator configurations. Clearly, however, the TCT with its two communication channels will have many fewer interaction possibilities than will the TCS with its

sixteen channels. In a recent operational test, one TCT at the level of corps was connected to two other TCTs at subordinate echelons, providing a simple tree structure arrangement. Presumably, this structure could be extended as desired, with each TCT at one level connected to two below it.

Presumably, however, TCTs in general will be connected to TCSs as the system evolves, so that the greater storage capacity and computational power of the larger machine will be available to a larger user/operator community. In addition, the assumption seems reasonable that TCSs will be interconnected, and that some TCTs will gain access through other, intermediate, TCTs.

If these speculations are valid, then one can expect quite complex user/operator configurations to emerge as the system continues to evolve. Interactions among the members of these configurations, with personnel of varying functional areas, grades, and skill levels, could well become a source of degradation in overall system performance. Thus, while little of substance can be said about this topic at present, it is one that should be considered carefully during planning for future steps in system evolution.

CONCLUSIONS

As noted in the Introduction, comparison of TCT with other systems is not a purpose of this report. However, one comparison is inescapable to anyone who has looked at TCT and any of the Army's older systems: the differences between designs for user/operator transactions. That comparison reveals the Army's growing recognition that concern for the user/operator is a legitimate issue in the design of battlefield automated systems. The above summary of the findings of this analysis of TCT transaction features clearly shows both hardware and software features designed to support and facilitate the user's/operator's efforts to perform transactions. The use of menus to present legal entries for data fields is merely one example.

In general, deficiencies in the software interface discovered with the Transaction Feature Analysis of TCT are minor (although a few are potentially serious, as noted in the Appendix). None of them could reasonably be expected to result in catastrophe. Even so, system developers should consider them carefully, because alleviating or eliminating even minor deficiencies results

in greater user/operator acceptance of the system, a lower level of frustration, and improvements in performance (of course, the caveat regarding feasibility, expressed under Recommendations, applies here also).

More importantly, TCT developers should consider seriously seeking frequent or even regular human factors assistance with the design of the software interface. Subject matter experts have indicated that the TCT will be developed with an evolutionary approach. As more capabilities are added, the system will become increasingly complex, and concern for the user/operator will become increasingly urgent. As one expert noted, when communications go from 2 channels to 16 with the advent of the TCS, initialization could become a "nightmare." Techniques such as the Transaction Feature Analysis could help to prevent this nightmare, and to continue the TCS/TCT's development as an easy to use, "friendly" system.

RECOMMENDATIONS

As noted in the Introduction to this report, recommendations for changes to the TCT or any other system are not a major purpose of this project. Nevertheless, the design of the Transaction Feature Analysis Technique leads to a recommendation to resolve each feature design problem discovered by using it. Thus, the reader will find a recommended resolution for each of the TCT deficiencies described in the Appendix. These recommendations, it should be noted, do not take into account any hardware, programming, or documentation constraints inherent in the current configuration of the TCT that might preclude implementing such recommendations.

Providing an automatic transition from page 1 to page 2 of the initialization procedure (see Section 1.3 in the Appendix), for example, appears to involve only a minor programming modification. Changing the labels of the DATA ENTRY, TEXT EDIT, CYCLE MSG, and REPL keys, on the other hand, appears to involve considerable expense (hence the recommended resolution to the second analysis of Section 1.3 in the Appendix).

ARI and Synectics, however, are aware that such judgments on the part of outside observers too often overlook implications apparent only to one who

knows the system well. For this reason, recommendations in the Appendix are made on the working assumption that the developer can implement any and all of them. This working assumption is made, however, in full knowledge that the developer is in the best position to determine the feasibility of implementing a recommendation immediately in the present configuration, or the necessity of deferring it until a later generation of the system.

APPENDIX

TRANSACTION FEATURE ANALYSES OF THE TCT

1. CONTROL METHODS

1.1 Command Language

TCT does not incorporate a command language *per se*. System commands are executed either by keying in menu selections or by pressing appropriate function keys.

1.2 Menus

Menus are employed in TCT; in general, they are well-designed from the user's/operator's point of view. No menu features required Transaction Feature Analysis.

1.3 Function Keys

- *Transaction Feature*. TCT initialization procedure.

  Description. The TCT must be initialized each time the system is moved, and each time task organization changes the configuration of communications equipment and computer terminals. The initialization procedure involves two "pages" of display formats, into which the user/operator enters initialization data. There appears to be no conceptual distinction between pages 1 and 2; they are always completed in the same sequence, and both pages must be completed to initialize the TCT. Available documentation describes no processing options after page 1 is completed; the user/operator must proceed to page 2. However, to obtain page 2 displays, the user/operator must press the DATA INIT and CHNG FCTN keys.

  Behavioral Implication. The user/operator must remember, first that function keys are required to obtain page 2 displays, and second the proper sequence of key presses. While not great, the memory and administrative burden imposed upon the user/operator by this requirement are unnecessary.

  Transactional Implication. Completion of initialization transactions will be delayed if the user/operator must refer to off-line sources to determine the method of transition from page 1 to page 2.

  Consequence of the Problem. Use of the TCT network will be displayed. In a fast-moving situation, any delay in processing tactical data could be critical to successful mission accomplishment.

Recommended Resolution. Modify system software to proceed automatically to page 2 after the final entry in page 2 is completed. Appropriate error checking and administrative procedures should be completed before jumping to page 2. An "exit" mechanism may be appropriate, so the user/operator can terminate initialization when conditions dictate.

Transaction Feature. Mode selection.

Description. At various points in TCT operations, the system presents a "mode selection alert" to the user/operator. This alert indicates that the user/operator must select one of the system's available modes of operation. The mode selection procedure is not uniform for all modes, however.

a. To select the TEXT EDIT or DATA ENTRY modes, the user/operator must press and hold down the interlock key (INTLK) while simultaneously pressing the appropriate mode selection key.

b. To select the CYCLE MSG or REPL modes, the user/operator merely presses the appropriate mode selection key, the INTLK key need not be used.

The system does not provide any prompts as to when the interlock key is required or not required.

Behavioral Implication. The user/operator must remember which modes require the interlock key, and which do not. This requirement imposes an unnecessary memory burden.

Transactional Implication. Failure to press and hold down the interlock key will prevent selection of the TEXT EDIT or DATA ENTRY mode. System documentation does not explain what will happen if the user/operator erroneously presses and holds down the interlock key when trying to select CYCLE MSG or REPL key.

Consequence of the Problem. System operations will be delayed while the user/operator diagnosis and corrects the error. Tactical data processing is delayed.

Recommended Resolutions. Two resolutions are possible:

(1) Provide a prompt with each mode selection alert such as the following.

TO INITIALIZE THE SYSTEM, PRESS AND HOLD DOWN INTLK KEY WHILE PRESSING DATA ENTRY KEY.

TO COMPOSE A NEW MESSAGE, PRESS AND HOLD DOWN INTLK KEY WHILE PRESSING TEXT EDIT KEY.

TO DISPLAY A MESSAGE THAT IS WAITING, PRESS CYCLE MSG KEY.

TO RECALL A MESSAGE THAT YOU'VE SAVED, PRESS THE REPL KEY.

(2) Require the user/operator to press and hold the interlock key while pressing the appropriate mode selection key for all mode selections. This procedure, while superfluous for CYCLE MSG and REPL, would at least make the mode selection procedure consistent for all modes, thereby reducing the user's/operator's memory burden.

Of the two alternatives above, the first is preferrable, because the second requires unnecessary keystrokes. However, if the first alternative is not feasible, the reduced memory burden outweighs the unnecessary keystrokes for CYCLE MSG and REPL.

Transaction Feature. Terminology used to designate modes.

Description. The TCT has four different modes of operation, with a specific term used to designate each mode, as follows:

Mode of Operation	Mode Designator
Initialize system configuration	DATA ENTRY
Compose a new message	TEXT EDIT
Display next message in queue	CYCLE MSG
Call up a message saved during a previous transaction	REPL

Each mode is selected by pressing one or more function keys (see preceding Transaction Feature Analysis).

Behavioral Implication. The four mode designators are not associated with their respective modes of operation in a natural, obvious manner. Therefore, the user/operator must learn an "unnatural" association. Particularly under stress, the user/operator may forget these associations.

Transactional Implication. Failure to press the proper mode selection key will call up an undesired display format. The user/operator may fill in part or all of the format before realizing the error--or even complete the format and enter it for processing.

Consequence of the Problem. At best, tactical data processing will be delayed while the user/operator corrects the mode selection error. At worst, data may be entered at inappropriate locations. Message recipients may be confused or misled.

Recommended Resolutions. Change function key labels, system software, and documentation to use more natural terminology. Examples of such terminology follow:

Mode of Operation	Mode Designator
Initialize system configuration	SYS INIT or CONFIG
Compose a new message	COMPOSE
Display next message in queue	NEXT MSG
Call up a message saved during a previous transaction	RECALL

1.4 Hybrid Methods

- *Transaction Feature*. Correspondence between software and function key label.

  Description. At appropriate points during TCT operations, a message appears in the user/operator alert area, instructing the user/operator to PRESS FORMAT DIRECTORY KEY. However, the key itself is labeled FRMT DIR.

  Behavioral Implication. Although the word FORMAT appears directly above the FRMT DIR key on the keyboard panel, some users/operators may initially look for a FORMAT DIRECTORY key, or fail to recognize the abbreviations used to label the key.

  Transactional Implication. Transaction completion may be delayed at least momentarily while the user/operator mentally translates FORMAT DIRECTORY from the prompt to FRMT DIR on the key. Failure to translate quickly or correctly would delay transactions further.

  Consequence of the Problem. At least momentary delays in tactical data processing, with delays lengthened if wrong button is pushed by a confused user/operator.

  Recommended Resolution. The lack of correspondence between terminology used in the prompt and on the key doubtless is not serious and probably won't increase error rates greatly. However, the probability of errors and delays will be reduced if the message in the alert area is changed to read PRESS FORMAT DIRECTORY (FRMT DIR) KEY or simply PRESS FRMT DIR KEY. This change would bring the message and the function key label into agreement.

1.5 Prompts/Helps

- *Transaction Feature*. Data entry into SITREP message.

  Description. The TCT Situation Report (SITREP) is used to inform higher echelons of a unit's status. Sixteen blocks are provided for reporting equipment, personnel, and ammo availability for crewed systems. Nine of these blocks have default system names

(ATKHEL, UHI-MSG, etc.). If the user/operator wishes to input the status of other systems, the item description is constrained to ten characters or less.

Behavioral Implications. The user/operator must fit any item description into the ten-character space. "5-TON TRUCK," for example, won't fit, and would have to be truncated or abbreviated. In such cases, the user/operator must decide whether to truncate or abbreviate, and if the decision is to abbreviate, must construct the abbreviation.

Transactional Implication. The user's/operator's decision process will consume time, delaying completion of the transaction. Constructing an abbreviation also will consume time.

Consequence of the Problem. Information on the unit's status will reach higher echelons slower than necessary. Delay could be critical in an urgent tactical situation.

Recommended Resolutions. Two resolutions are possible:

(1) Delete the seven elements of the system status block that are provided for optional systems. Provide a message at the bottom of the block saying "USE REMARKS FIELD IF ADDITIONAL ITEMS MUST BE ENTERED."

(2) Modify the software to provide a hierarchical menu of all crewed systems, with item descriptors formatted at ten characters or less.

The choice between the above options appears to depend on considerations of implementation.

- *Transaction Feature*. Mode selection after initialization.

Description. After the user/operator has initialized the TCT, the message "INITIALIZATION IS COMPLETE" appears in the operator alert area of the display screen. At this point, the user/operator must select one of the system's four modes of operation in order to continue processing. However, the system provides no indication that the user/operator must take some action.

Behavioral Implication. The user/operator must remember that an action is necessary after the "INITIALIZATION IS COMPLETE" message appears. In this situation, an inexperienced user/operator, or one under stress, may simply wait for the system to provide instructions for the next transaction. Even if he or she remembers that a mode must be selected, the user/operator must still recall the four modes of operation and their associated designators.

Transactional Implication. If the user/operator simply waits for instructions, transactions will be delayed, for an unpredictable period. Or, the user/operator may attempt to select an illegal mode.

Consequence of the Problem. Tactical data processing will be delayed. Information needed by command and control personnel will reach them later than necessary.

Recommended Resolution. Modify TCT software to provide an automatic transition to "SELECT A MODE" message in alert area, accompanied by prompt for mode selections (see 1.3 FUNCTION KEYS, above).

- *Transaction Feature*. Prompts for channel characteristics.

Description. During TCT initialization, the user/operator specified the characteristics of communications channels, selecting from menus. For example, to select the device:

1. KY-57
2. MODEM
3. CAU
4. LOCAL RADIO
5. REMOTE RADIO
6. 2-WIRE
7. 4-WIRE
8. CURRENT LOOP

Behavioral Implication. Some of the terminology used in the menu (e.g., KY-57, MODEM, CURRENT LOOP) may be excessively technical for users/operators, forcing them to remember unfamiliar designations.

Transactional Implication. Initialization transaction may be completed incorrectly.

Consequence of the Problem. The TCT communications channel may be configured erroneously, preventing communications, or establishing communications with an inappropriate unit.

Recommended Resolution. Provide menu options that are meaningful to the user/operator. For example, explain briefly what a KY-57 is, what it does, or what it looks like if it's located where the user/operator can see it.

- *Transaction Feature*. Initialization menu options.

Description. At some points in the initialization process, the TCT displays menu options for communication channel characteristics that are illegal, given the characteristics already selected.

For example, if "NRZ" is the selected modulation, then only 1200, 2400, 4800, and 9600 are valid data rates. However, the system presents all 11 of the available data rates.

Behavioral Implication. The user/operator must remember, for each successive menu, which options remain valid, given earlier menu selections. This requirement imposes an unnecessary memory burden on the user/operator.

Transactional Implication. Selection of an invalid menu option will invoke error diagnostic and correction procedures, delaying completion of the initialization transaction.

Consequence of the Problem. Availability of the TCT to its user community will be delayed.

Recommended Resolution. Modify TCT software to use information already provided by the user/operator to determine options presented in subsequent menus. (NOTE: TCT already does this, but only in the case when only one option is valid, or when no options are valid). Figure A-1 presents an example. The first menu in each column permits the user/operator to select the device; as noted at the bottom of the menu, the selection is "3" for "CAU." Since the CAU uses only NRZ modulation, the modulation menu is not presented. Then, in the data rates menu, the system presents only data rates that are valid for NRZ modulation.

- *Transaction Feature*. Compatibility of prompts.

Description. In the SITREP and GRAP message formats, the prompt for identifying the receiving terminal node is:

"ENTER THE NUMBER (00-99) THAT IDENTIFIES THE TERMINAL TO RECEIVE THIS MESSAGE"

The SPOT and FREE message formats also require the user/operator to identify the receiving terminal node. However, in these two messages, the prompt is:

"ENTER THE NUMBER IDENTIFYING TERMINAL TO RECEIVE THIS MESSAGE"

Behavioral Implication. The difference in wording between the two functionally identical prompts provides an unnecessary opportunity for confusion. The failure to indicate the range of legal values in the second prompt adds another opportunity for confusion in the SPOT and FREE messages.

Transactional Implication. If the user/operator becomes confused, time will be required to resolve the confusion. Also, the user/operator is more likely to enter an invalid numeric value in the SPOT and FREE messages than in the SITREP and GRAP messages.

CURRENT PROMPTING	REVISED PROMPTING
ENTER DEVICE: 1. KY-57 2. MODEM 3. CAU 4. LOCAL RADIO 5. REMOTE RADIO 6. 2-WIRE 7. 4-WIRE 8. CURRENT MODULATION User/operator enters "3" to specify "CAU"	ENTER DEVICE: 1. KY-57 2. MODEM 3. CAU 4. LOCAL RADIO 5. REMOTE RADIO 6. 2-WIRE 7. 4-WIRE 8. CURRENT MODULATION User/operator enters "3" to specify "CAU"
ENTER DATA RATE: 1. 75 2. 150 3. 300 4. 600 5. 1200 6. 2400 7. 4800 8. 9600 9. 8000 10. 16000 11. 32000 User/operator should enter only 5, 6, 7, or 8.	ENTER DATA RATE: 5. 1200 6. 2400 7. 4800 8. 9600 Only valid data rates are presented

Figure A-1. Example of channel characteristic specification

Consequence of the Problem. Tactical data processing is delayed for whatever time is required to resolve confusion. An illegal terminal node number will delay processing further.

Recommended Resolution. Modify system software so that functionally identical prompts are worded identically. In this case, the SITREP and GRAP prompt should be used for the SPOT and FREE messages as well, because it includes information about legal values.

2. DISPLAY FORMAT

The four message formats currently implemented in TCT are consistent in design, and appear to be properly formatted from the user's/operator's point of view. None of the features of display formats appeared to require Transaction Feature Analysis.

3. DATA ENTRY ASSISTANCE

3.1 Information on Legal Entries

- *Transaction Feature*. Legal entry information for TEXT EDIT mode.

  Description. In the TEXT EDIT mode, the TCT provides variable function keys (VFKs) for PREV ENTRY, NEXT TOPIC, PREV TOPIC, and NEXT LINE. These keys are labeled clearly in the area of the screen set aside for VFK labels. However, the system provides no information on-line to tell the user/operator which of the fixed function keys (FFKs) are legal in the TEXT EDIT mode.

  Behavioral Implication. The user/operator must rely on memory to identify legal FFKs in the TEXT EDIT mode. Attemtps to use illegal FFKs will lead to errors or to user/operator frustration when the system does not respond.

  Transactional Implication. Completion of message composition transactions will be delayed while the user/operator "tries out" various FFKs or refers to offline sources.

  Consequences of the Problem. Tactical data processing will be delayed. Information required by message recipients will be received later than necessary.

  Recommended Resolution. Two alternatives exist:

  1. Provide prompts indicating which FFKs may be used in the TEXT EDIT mode.

2. Provide a "help" capability through which the user/operator can find out which FFKs are legal in the TEXT EDIT mode.

3.2 Unburdening of Input

- *Transaction Feature*. Entry of unit IDs for message sender and message recipient during message composition.

  Description. When composing a SITREP, SPOT, UTO, or FREE message the user/operator must enter the unit ID for the sender of the message and for its recipient. Each of these unit IDs requires 7 separate entries, with a total of up to 20 characters.

  Behavioral Implication. To identify both sender and receiver, the user/operator must enter up to 40 keystrokes. Though TCT provides sequential prompting and examples to assist the procedure, the user/operator may enter typographical errors.

  Transactional Implication. Any keystroke error will either (1) direct the message to an inappropriate recipient; (2) misidentify the sender of the message; or (3) cause an error message to the user/operator.

  Consequences of the Problem. Error messages to the user/operator will delay transactions and hence reduce the system's processing rates. Misdirection of message or misidentification will cause confusion, with unpredictable but clearly undesirable consequences to the mission.

  Recommended Resolution. Evidently, message traffic generally will occur among limited numbers of units. For example, a given battalion normally would communicate only with neighboring battalions and (perhaps primarily) with its brigade headquarters. If most traffic thus involves a limited number of units, provide a menu listing these units so that the user/operator can identify sending and receiving units with a minimum of keystrokes. In addition to reducing typographical errors, data entry would be speeded up. "NONE OF THE ABOVE" could be the final option, for those cases when the menu does not include the required unit ID. Then, the current entry method could be involved.

- *Transaction Feature*. Entry of date information.

  Description. In each TCT message, the user/operator must enter the date, clock time, zone, month, and year to specify the time of message composition.

  Behavioral Implication. On a given day, all but clock time are repetitious from message to message. In addition to the potential for typographical errors, this repetition imposes an unnecessary administrative burden on the user/operator.

Transactional Implication. Typographical errors, if detected, will require reentry, delaying completion of the transaction. If undetected, erroneous information will be transmitted to the recipient.

Consequences of the Problem. Transaction delays cause delays in tactical data processing. Also, erroneous TRANS-TIME information could mislead the recipient as to the currency of information.

Recommended Resolution. Provide a topic or field allowing the user/operator to enter the date, zone, month, and year during system initialization. Also provide a separate message to allow the user/operator to change the date in case of error or date change prior to next initialization. Then, modify TCT software to enter this information automatically into each message. If the system includes a real time clock, the time could also be entered automatically. Otherwise the user/operator is required to enter the time.

- *Transaction Feature*. Entry of EFF-TIME.

Description. When composing any message, the user/operator must enter date, time, zone, month, and year to designate when the message will become effective.

Behavioral Implication. As always, the possibility exists for typographical errors.

Transactional Implications. Detected errors will result in delay during error diagnosis and correction procedures. Undetected errors will be transmitted.

Consequences of the Problem. Transmission of messages may be delayed. Undetected errors in effective time could have unpredictable but profoundly serious consequences.

Recommended Resolution. In the prompt area, present the TRANS-TIME as a candidate EFF-TIME. Provide the capability to modify the candidate time only as required to generate the required EFF-TIME. For example (user Responses underlined):

TRANS-TIME IS 112115ZDEC 80.

IS THIS THE EFF-TIME (Y or N): Y

(TRANS-TIME is copied into EFF-TIME, and system proceeds to next topic).

TRANS-TIME IS 112115ZDEC 80.

IS THIS THE EFF-TIME? (Y or N): N

IS DATE FOR EFF-TIME 11? (Y or N): Y

IS TIME FOR EFF-TIME 2115? (Y or N): N

ENTER TIME FOR EFF-TIME (4 Digits): 2330

IS ZONE FOR EFF-TIME Z? (Y or N): Y

IS MONTH FOR EFF-TIME DEC? (Y or N): Y

IS YEAR FOR EFF-TIME 80? (Y or N): Y

Each time the user'operator responds to a prompt with "Y," the system copies the item of information from the TRANS-TIME to the EFF-TIME. When the response is "N," the system provides a prompt to obtain the required prompt.

- *Transaction Feature*. Specification of communication channel characteristics.

Description. During TCT initialization, the user/operator must enter communication channel information for both channel 1 and channel 2. Channel 2 information must be entered even if it is identical to channel 1 information.

Behavioral Implication. The user must enter the same information item twice whenever characteristics are the same for both channels. This requirement imposes unnecessary work for the user/operator, and provides unnecessary opportunities for typographical errors.

Transactional Implication. Typically, initialization transactions require more time than necessary to complete. Errors, of course, delay completion of the transaction even more.

Consequences of the Problem. The TCT is unavailable to its user community for longer than necessary.

Recommended Resolution. Each time an entry is to be made for channel 2, provide, the capability for the user/operator to simply press the ENTER key or a VFK to copy information for channel 1 into channel 2.

3.3 Interrupts and Work Recovery

- *Transaction Feature*. Retransmission of message which could not be transmitted initially.

Description. If channels are tied up, a message may fail to be transmitted when the XMIT key is pressed. If so, the message, "WAIT. PUSH XMIT AGAIN" appears in the Operator Alert area of the display. The user/operator is then expected to wait 30 seconds and press the XMIT key again.

Behavioral Implication. The user/operator must remember that the message has not been transmitted, and must estimate a 30-second elapsed time while performing other tasks. The user/operator may forget that a message is waiting to be transmitted, or may get involved in other tasks and misestimate the amount of time which has elapsed since the "WAIT. PUSH XMIT AGAIN" message appeared.

Transactional Implication. No appreciable effect on the transaction itself, since message composition has been completed.

Consequences of the Problem. Message transmissions may be delayed longer than necessary. Note that this situation may be particularly serious at times of crisis, when the user/operator is likely to be under stress, and these conditions are likely to exist:

1. The user/operator is trying to do many tasks rapidly to keep up with a flood of incoming and outgoing information.

2. Communications channels are heavily loaded, increasing the probability that getting channel access will be difficult.

Recommended Resolution. There are at least two possible solutions:

1. Automated solution. Provide software to have the system remember that a message could not be transmitted. Accessing the real time clock would permit the system to tell how long a message has been in the XMIT buffer without being sent. The equipment could try every *n* seconds to transmit, or could poll the common line until free. Information could be displayed to indicate to the user/operator the status of the message in the XMIT buffer:

   MSG NO. _ _ _ _ _

   TIME SINCE FIRST XMIT ATTEMPT _ _ _ _ _

   # OF ATTEMPTS TO XMIT _ _ _ _ _

   This capability should include some method for alarming the user/operator when the message has been in the buffer "too long." One could perhaps have both a default and user-selectable threshhold for "too long."

2. Semiautomated solution. Again, using a link to the real-time clock, alarm the user/operator when 30 seconds have passed. This will assure that the user/operator does not forget about a message sitting in the output buffer.

4. MESSAGE COMPOSITION AIDS

4.1 System Design Features

- *Transaction Feature*. Feedback of data entries.

  Description. As the user/operator selects options from menu prompts, the associated information appears in the proper position of the message display area. However, no comparable feedback appears in the prompt area.

  Behavioral Implication. To verify the accuracy of data entry, the user/operator must locate the information in the format displayed in the message display area. Shifting focus between the message display and prompt areas of the screen may cause eye fatigue and increases the time required to locate information for verification.

  Transactional Implication. Potential for error is increased; time to input the data is increased.

  Consequences of the Problem. Slow down of system operation.

  Recommended Resolution. Generate data entry feedback in a consistent position near the prompt area.

- *Transaction Feature*. Entry of hardware configuration specification at system initialization.

  Description. The user/operator must provide specifications for communication devices to which the TCT interfaces. Initialization must be performed each time the system is powered up, even though identical data may be entered each time.

  Behavioral Implication. The user/operator expends unnecessary time in specifying hardware configuration repetitively.

  Transactional Implication. Unnecessary time is spent in system initialization.

  Consequences of the Problem. Potential for reduced system throughput.

  Recommended Resolution. Provide default initializations for all communications equipment, with capability for the user/operator to alter specifications as necessary.

- *Transaction Feature*. Entry of grid zone designation. (NOTE: This Transaction Feature Analysis is valid only if grid zone refers to the physical location of the equipment, rather than the location of the organizational units which use the equipment as a communications mechanism.)

Description. The user/operator enters a grid zone for each message, whether or not the TCT has moved.

Behavioral Implication. The user/operator must recall and accurately enter the grid zone designation.

Transactional Implication. Erroneous grid zone information can be transmitted to message recipient.

Consequences of the Problem. Inaccurate grid zone designation could cause confusion for the message recipient in regard to the information source.

Recommended Resolution. Include specification of the grid zone designation as part of system initialization and enter it automatically into the standard message formats. However, if the equipment can be moved without re-initialization, the user/operator must remember to change the grid zone designation.

4.2 Format for Alphanumeric Messages

No features relevant to the message formats requiring Transaction Feature Analysis were observed.

4.3 Graphic Displays

A graphics capability is planned for TCS/TCT but to date has not been implemented.

5. DATA RETRIEVAL ASSISTANCE

No TCT data retrieval assistance features were observed that required Transaction Feature Analysis.

6. GLOSSARIES

No TCT glossary features were observed that required Transaction Feature Analysis.

6. Abbreviation and Coding

No TCT abbreviation and coding features were observed that required Transaction Feature Analysis.

7. ERROR HANDLING

7.1 Error Prevention

No TCT error prevention features were observed that required Transaction Feature Analysis.

7.2 Error Detection

No TCT error detection features were observed that required Transaction Feature Analysis.

7.3 Error Feedback

- *Transaction Feature*. Presentation of legal entry information; error information.

  Description. In various modes of operation with the TCT, the user has several allowable options which may be exercised by pressing one of the TCT function keys. If the user attempts to exercise an invalid option, the message:

  "INVALID ENTRY. TRY AGAIN"

  is displayed. No explanation of the error is provided.

  Behavioral Implication. The user/operator is forced to determine why entry was invalid through either short term memory--recall of which key was pressed, or long term memory--recall of procedural validity trees.

  Transactional Implication. Transactions may be delayed while the user/operator diagnoses and corrects the error.

  Consequences of the Problem. Potential for operator confusion and unnecessary system delay.

  Recommended Resolution. Display informative error messages, such as:

  FUNCTION _ _ _ _ _ _ _ _ _ IS NOT ALLOWED IN THE _ _ _ _ _ MODE;
  YOU CAN USE:

  1.

  2. (List of legal functions)

  3.